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Ann P. Hopper Dr

Controlled Modifications of Surface at the Nano-Scale.

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This seminar was organised by Greg Payne, Kevin McGlinchey and Ann Hopper on behalf of the Irish Branch of the Institute of Material Finishing. This full day meeting was held on 17th September 2013 in Seagate Derry/Londonderry . It consisted of 6 presentations by key users and researchers of surfaces at the nanoscale with emphasis on highlighting recent developments in a range of novel surface modification and process control technologies, used in the manufacture of precision components.

The IMF seminar was hosted and supported by Seagate as part of the Seagate celebrations of 20 years in Ireland. It was also the launch of the name change from the Institute of Metal Finishing to the Institute of Material Finishing with the inaugural Gold Medal award of the Irish branch being presented to Prof. Martyn Pemble.

Figure 1 Mr Greg Payne of Seagate Technology

The seminar was opened by **Damien Gallagher, (**Engineering Director Seagate) who gave an overview of Seagate as they develop the technologies which will facilitate the exponential growth in data volumes from 400 exabytes (10^{18}) to 5 zettabytes (10^{21}) and the shift to cloud storage over the rest of the decade.

The Springtown facility makes the recording heads which goes into the head gimbal assembly on hard drives for computers. They are one of the largest fabs in the world for this technology with over 25% of the world's recording heads coming from this facility. What an electronic marvel the giant magnetic resistor is was explained by Damian as the head is 40 atoms across with a flight height of 10 nanometers at a speed of 15,000 rpm reading and writing data, this is analogous to a 747 aeroplane going at 800 times the speed of sound, less than one centimetre above the ground counting every blade of grass (with an error of < 10 blades) over an area the size of Ireland. A fact that is difficult to comprehend.

The second speaker **Dr Peter McGeehin** (Seagate R&D Engineering) gave a talk on utilising Galvanic Couples for the Chemical Mechanical Planarization (CMP) of nano-structures. CMP is well known to those in the semiconductor and recording head industries as a process to flatten topography so that the next layer of patterned material in the 3D structure can be deposited. The primary agents involved in CMP are chemical dissolution and mechanical abrasion. The challenges of flattening an 8” wafer with uniformity of < 5 nm led to developments including an electrochemical element (promotion of the rate of metal oxide formation) to aid the mechanical robustness of Iron containing alloys. Problems arise due to the difference in centrifugal force between polishing the inner/centre portions of the wafer and the outer extremities/edges of the wafer. The patterned CoFe Write Pole has a covering of alumina and this topography must be flattened during CMP. The Write Pole must be of uniform thickness across the wafer post-CMP process. CMP too far and too much Write Pole material is removed. CMP too little and the Write Pole is not exposed above the alumina. By examining the corrosion chemistry of the particular slurry and by coupling the CoFe with a more noble metal forms a galvanic corrosion couple. Use a Platinum Group metal as a cathode and the CoFe as the anode, results in a galvanic current flowing from anode to cathode. The electron flow is from the CoFe anode (oxidation of Fe alloy to physically a harder oxide) to the Pt group cathode (where rate of Oxygen Reduction Reaction is enhanced) when the correct alkaline slurry is chosen. By increasing the rate of oxidation of the metal we increase the resistance of CoFe to mechanical abrasion of CMP process. Thus, anodic protection could be achieved, as the metal oxide is more resistant to polishing. This was a very fine paper to lead the way from “metal” to “material” finishing as an example where corrosion (oxidation) is not always a bad thing and can even be beneficial if the correct media is chosen.

Polishing or more precisely polish grinding to achieve nanometer surface finish was the subject from **Dr Peter Dennis** (3M Superabrasives Fine Grinding). The technology of fine grinding versus lapping was explained, where fine grinding does leave scratches in the surface this has a beneficial property in the sealing between steel to steel, other advantages are the reduced cutting force, larger removal rates and the beneficial characteristics of low subsurface damage. The latest technology tooling controls accurately the work piece path forms determining precisely where it will contact the wheel. The work piece guidance with lapping kinematics on super abrasive wheels allows grinding wheel specifications to be varied to customised work pieces. Due to the steady increasing requirements of work pieces with desired roughness in the range on nanometers for polishing grinding, especially for hard brittle materials such as glass & sapphire, with mirrored surfaces new concepts were proposed based on alternatives to elaborating lapping procedures.

The read write head industry was discussed by the next speaker, **Zhenqi Lu** (Seagate Technology) Plating Shield incorporating synthetic antiferromagnetic seed for enhancement of magnetic anisotropy.

NiFe alloy is the generally preferred material for shields in read write technology due to its near zero magnetostriction and low coercivity. As long as the areal density of read write heads was still in the high sub-micron region the Barkhausen effect has been negligible. Barkhausen effect is that of induced noise on a ferromagnet when the magentising force switches. The read element has necessarily become smaller, more sensitive leading to a Shield to Shield spacing of the order of 28 nm. This means the reader is more susceptible to barkhausen noise. Lu has investigated a solution by enhancing the magnetic anisotropy of shield films by adding a synthetic antiferromagnetic material into the stack. A very thin layer of ruthenium, (0.8 nm) acts as a seed layer with a layer of nickel iron plated on it to form a shield for a read element in the recording head. A lively discussion ensued on the complexity of analysing such a layer and how characterisation was critical to the process. The metrology of the product rather than any surface or chemical analysis could prove a uniform, continuous smooth layer by the stability of the domain configurations within shields.

After the lunch break **Denis Healy** (Division Manager Cutriss Wright Surface Technology, Galway) provided an insight into the use of Parylene as a conformal coating for electronics and medical devices. A brief history of the polymer, based on P-xylene, from its discovery in 1947 by Michael Szwarc (University of Manchester) to the development of the first coating provider by Trans Nova corporation in 1971 was given by the speaker. The four main variations and their properties highlight the potential applications in the medical device industry. The absolute conformance to substrate topography with the barrier properties including; Chemical, Moisture, Bio-fluids, Electrical (Dielectric) resistance has allowed FDA USP class VI & ISO 10993 approval for biocompatibility and bio-stability. The penetration characteristics and the fact that it remains pinhole free down very thin coatings are of interest in many applications. Some of these in the medical device field are Cardiac assist devices ICDs, pacemakers, VADs & Catheters & Delivery Systems.

One of the original uses of Parylene as a conformal coating in high end electronic circuit boards has returned as a mitigation method against tin whisker growth;- the curse of the electronics industry since the Pb-free directive or RoHS. Dr Healy produced evidence that Parylene is one of the most effective coatings against tin whiskers as it will reduce the rate of growth, though will not stop their formation. Dendrite and whisker growth has many possible cures and although mitigation may be beneficial Parylene's dielectric properties providing insulation against the "shorting" effect of tin whiskers touching adjacent components may its main advantage. A further application as a stress free ultrathin sandwich layer in electronic sensors was reported to be gaining acceptance in that area.

Figure 2 Prof. Martyn Pemble receiving the Irish gold medal from IMF president Dr. Paul Landsdell

There followed a break in the proceedings during which Prof Martyn Pemble was presented with the Irish Gold Metal by Dr Paul Lansdell. This is the inaugural award to be presented annually by the Irish branch to a company or individual who has excelled within the field of surface engineering in Ireland. Dr Paul Lansdell, as president of the IMF, welcomed all delegates and was delighted to present the award. He thanked Seagate for their hospitality and wished them success for the next 20 years in Ireland. He spoke of the name change from the Institute of Metal Finishing to that of the Institute of Material Finishing emphasising that we have changed from “metal” to “surface properties” and changing with the industries to become the interface between technologies; bringing people together for networking and a place to have a conversation, talking to each other about similarities of the industries we support.

Prof Pemble, in accepting the award for this work in atomic layer deposition technology stated that he was honoured to accept this award and wished the Institute every success in in its work of promotion of surface engineering.

After receiving his BSc and PhD degrees from the University of Southampton, Professor Pemble was in 1995 appointed to the Chair of Physical Chemistry at the University of Salford. In 2004 he moved as an SFI funded professor to the Tyndall Institute at University College Cork, where he now heads the Advanced Materials and Surfaces Group. In November 2008 he was appointed Stokes Professor of Materials Chemistry – a joint position between Tyndall and UCC Chemistry. Professor Pemble also gave the final presentation, on atomic layer deposition (ALD) and related technologies for next-generation materials manufacture. He leads the FORME strategic research centre cluster which targets collaboration between academia and industry. The themes of his speech ‘More Moore’ and ‘More than Moore’ were of great interest to the audience at Seagate.

He began with an explanation of the ALD process, demonstrating that deposition is self-limiting with growth of 0.4–0. 8 monolayers per cycle at temperatures less than 350^{0}C. Applications include the production of titanium nitride layers to uniformly fill the nanoporous structure in anodic aluminium oxide (AAO). The ability to produce uniform coatings on flat or complex 3D geometrics was demonstrated for aluminium oxide monolayers on DRAM capacitor trenches. Here, the pulsed sequencing of each precursor allows the production of uniform layers of aluminium oxide, with layer-on-layer build up. The ALD layer is uniform in gaps, corners and over 3D structures. The process can be used to coat oxides, nitrides and metals, semiconductors, polymers and other materials. Obvious uses are in semiconductor at the nucleation stage but Professor Pemble took the time to review work in other emerging applications.

Achieving ferroelectric behaviour at room temperature is an ongoing project using atomic vapour deposition. A chemicals deposition route is used that does not have problems with volatility so long as the chemical vehicle dissolves the precursor. The component can hold its shape when an electrical bias changes the ferroelectric material. These room temperature single phase magnetoelectric multiferroics could meet future industry requirements in high density memory applications. The use of ALD for coating of drug eluting stents is under investigation and showing some beneficial results. Since ALD is a cleaner system there is less build-up of material around the stent and there is evidence to show some improvement in stent thrombosis. Other prospects in the medical device field are polymer/inorganic oxide drug- containing coatings, for application on bone implants, e.g. long bone femoral nails, laid down by ALD or plasma assisted ALD. The objective being to resist bio-contamination (e.g. with proteins or microorganisms) and to facilitate less invasive removal. The final application discussed was ALD coatings on textiles to improve flame retarding properties. A 10 μm layer of aluminium oxide forms a crust seals the textile against the flame and assist in putting the flame out.

There followed a guided tour of the Seagate manufacturing facility where delegates had the opportunity to see examples of the controlled modifications of surfaces at the nanoscale for themselves.